BL1.4.2: Time-resolved FTIR spectroscopy at up to 5 nanosecond resolution demonstrated

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INTRODUCTION

Synchrotron-based infrared (IR) beamlines provide a unique opportunity for doing time-resolved IR spectroscopy. Synchrotrons operate with electrons travelling in bunches around the storage ring. Each bunch emits a pulse of synchrotron radiation every time the electrons are forced to turn via a bending magnet. The time structure of the light pulses is therefore determined by the filling pattern of the electron bunches. The ALS typically operates in multi-bunch mode with 288 bunches spaced 2 nanoseconds apart, followed by an 80nsec gap. The individual pulse width is 44psec (FWHM). This electron filling pattern is schematically drawn in Figure 1.

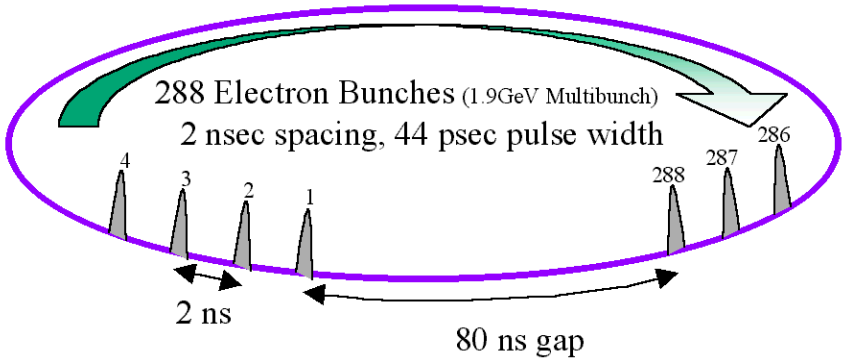

Figure 1. The ALS produces pulses at intervals of 2nsec, expect for a single long gap of 80ns. We use this time structure to demonstrate the fast timing capabilities of BL1.4.2.

Standard rapid-scan Fourier Transform Infrared Spectroscopy (FTIR) acquires scans on the time scale of one second, so the very fast pulses of a synchrotron source are not noticed. However, using the step-scan capabilities and fast electronics of the Bruker IFS66v/S FTIR spectrometer on BL1.4.2, we can measure IR spectra with a time resolution as fast as 5nsec. This means that processes which occur on the nanosecond all the way up to hour time scales can be probed spectroscopically on this beamline.

TIMING DEMONSTRATION

To demonstrate the fast-timing capabilities of this beamline, we synchronized the detection electronics with the ALS ring timing structure (one trigger per complete revolution of the electrons). IR spectra were then obtained at 5nsec time slices for a total of 650nsec. We plot the measured IR intensity as a function of time in Figure 2.

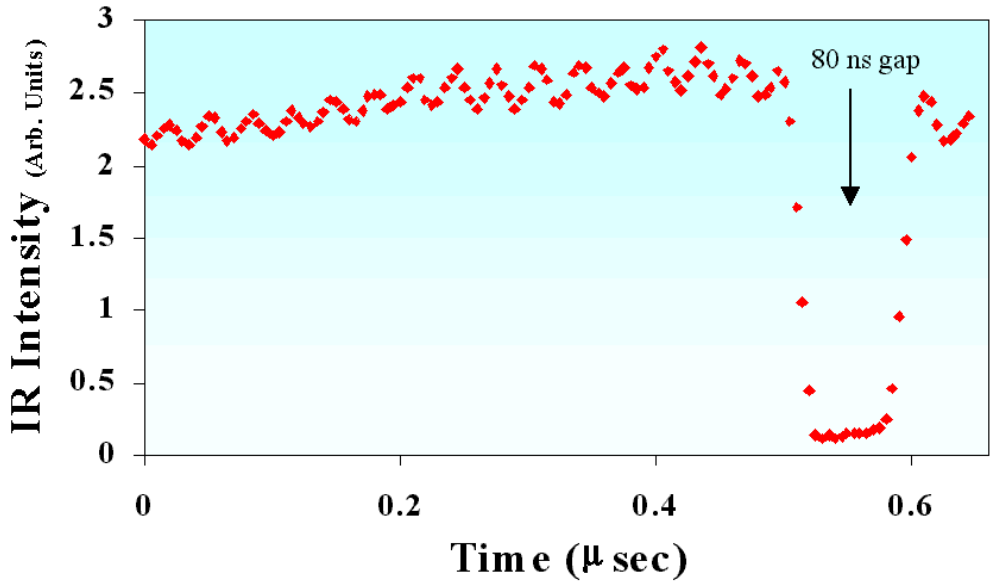

Figure 2. Time-resolved measurement of the IR intensity showing the 80 nsec gap in the ALS synchrotron filling pattern. The time resolution of the current electronics does not yet fully separate the 2 nsec spacing between pulses.

Figure 2 clearly shows that we can observe the 80 nsec gap in the synchrotron light pulses. The IR detector and digitization electronics are not yet fast enough to observe the 2 nsec pulse spacing, but forthcoming enhancements should allow sub-nanosecond timing enabling the use of individual synchrotron pulses to serve as the probe in very fast time-resolved experiments.

Typical applications for this beamline will include pump-probe measurements (semiconductors, metastable states), environmental science (adsorbates, bacteria, soil chemistry, bioremediation), biological materials (identification of biomolecules, time-resolved chemical reactions), high-pressure systems (materials in diamond anvil cells), and measurements in high-magnetic fields (reflectivity from high-T_c and other correlated electronic systems).

CONCLUSION

The step-scan capabilities of the IFS66v/S FTIR spectrometer on BL1.4.2 allow for very fast time-resolved IR spectroscopy. This instrument, in conjunction with the ALS synchrotron's pulsed nature, makes possible a host of new time-resolved and pump-probe spectroscopic experiments.

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